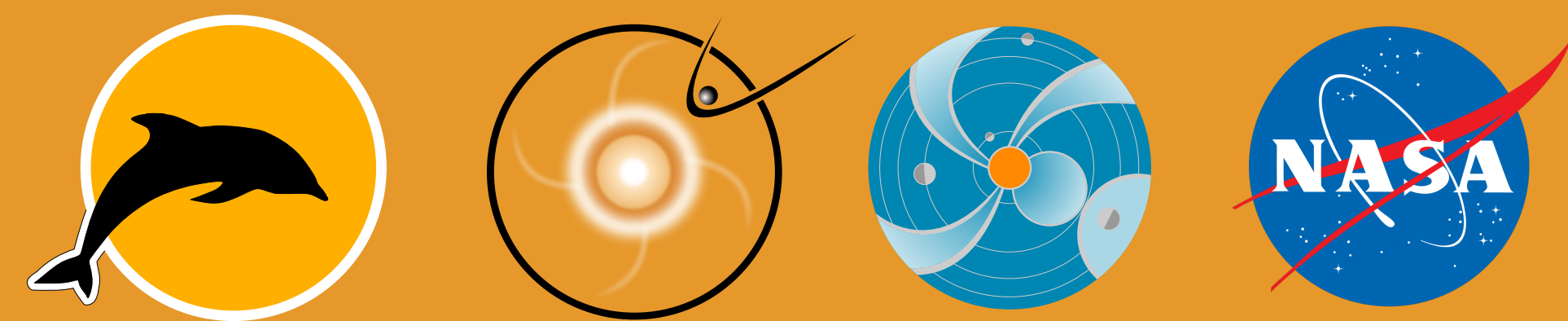


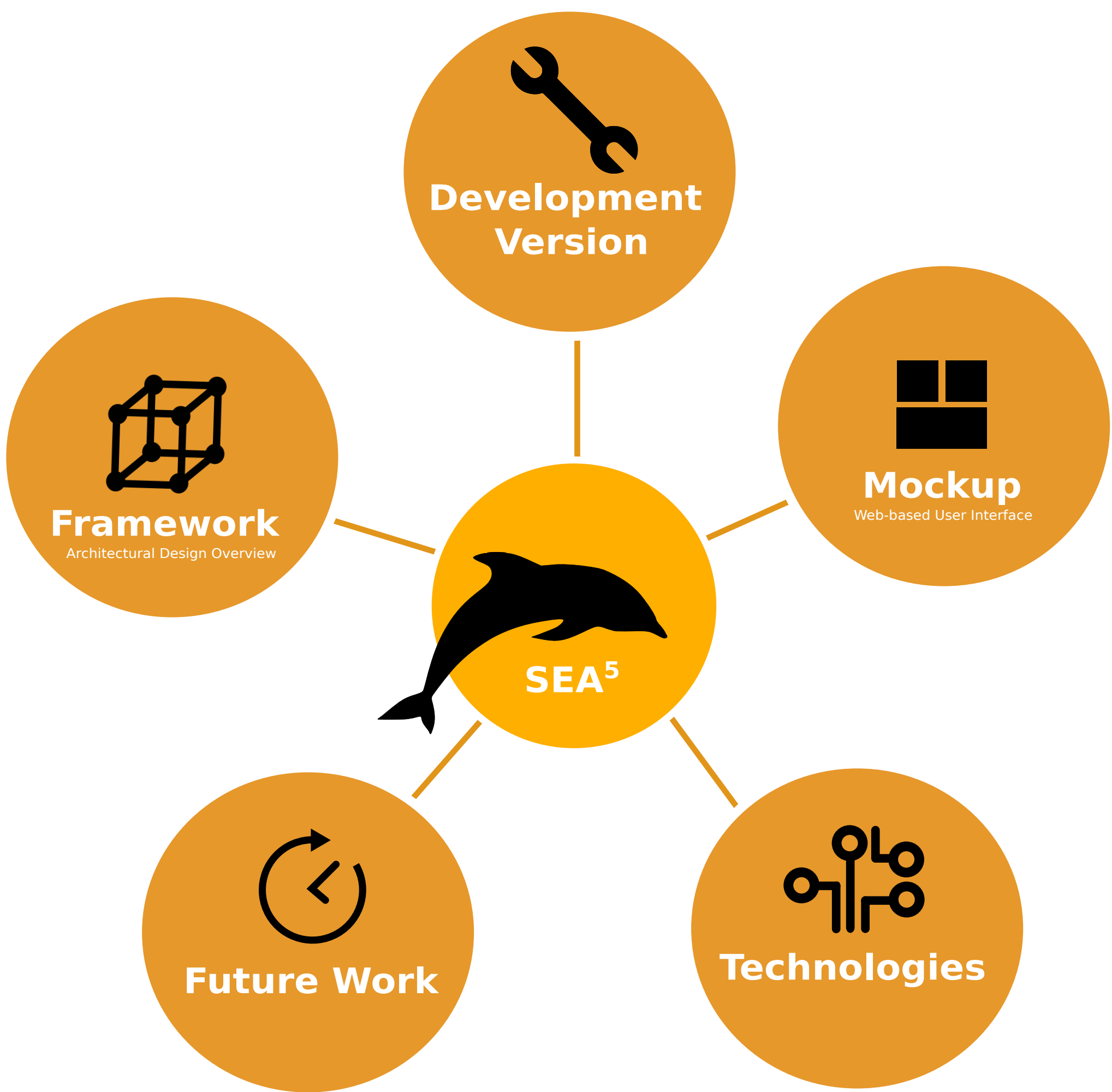
SEA⁵: Space Environment Automated Alerts and Anomaly Analysis Assistant

Developed by the Community Coordinated Modeling Center (CCMC)



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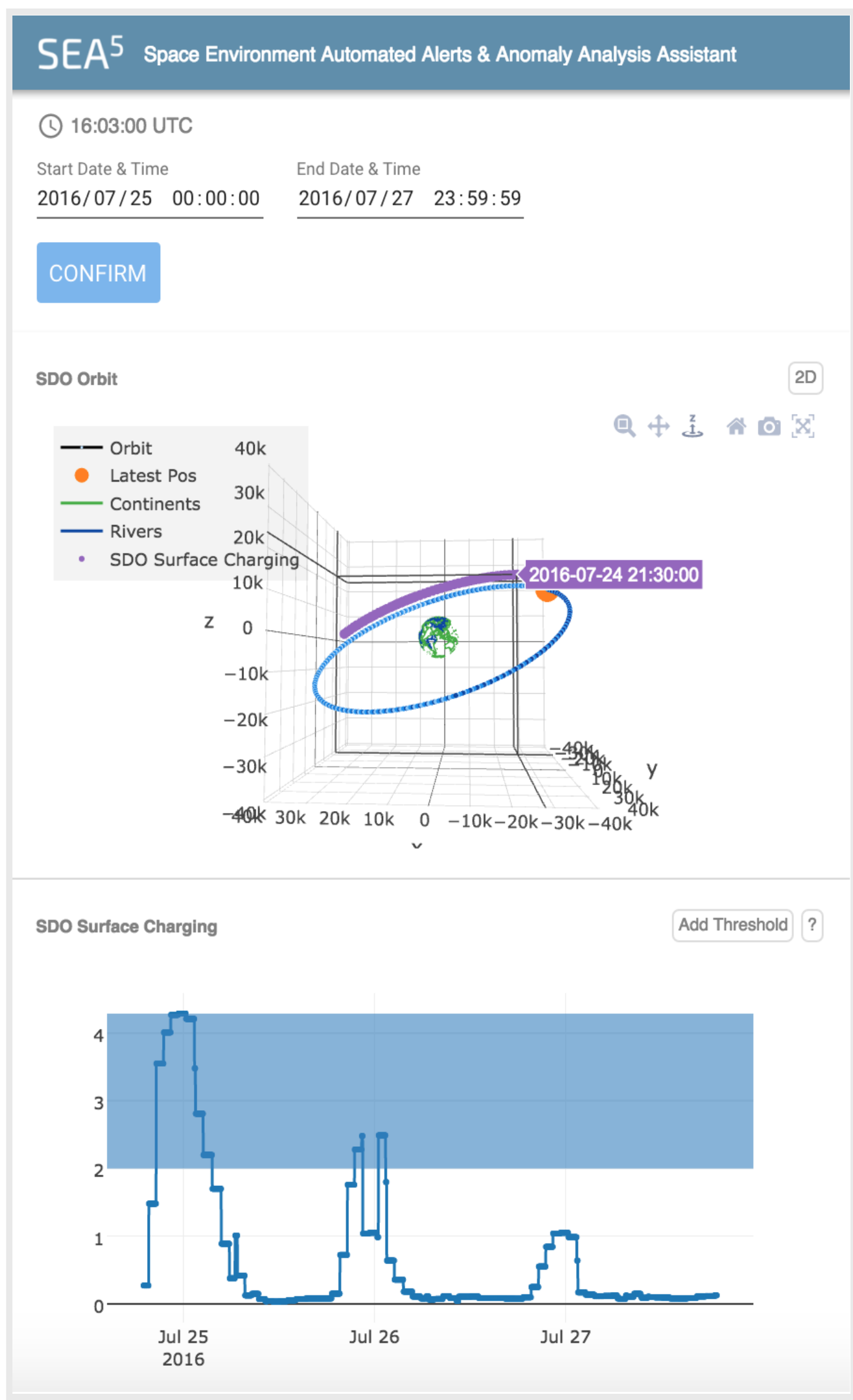
CCMC/SWRC, NASA Goddard Space Flight Center



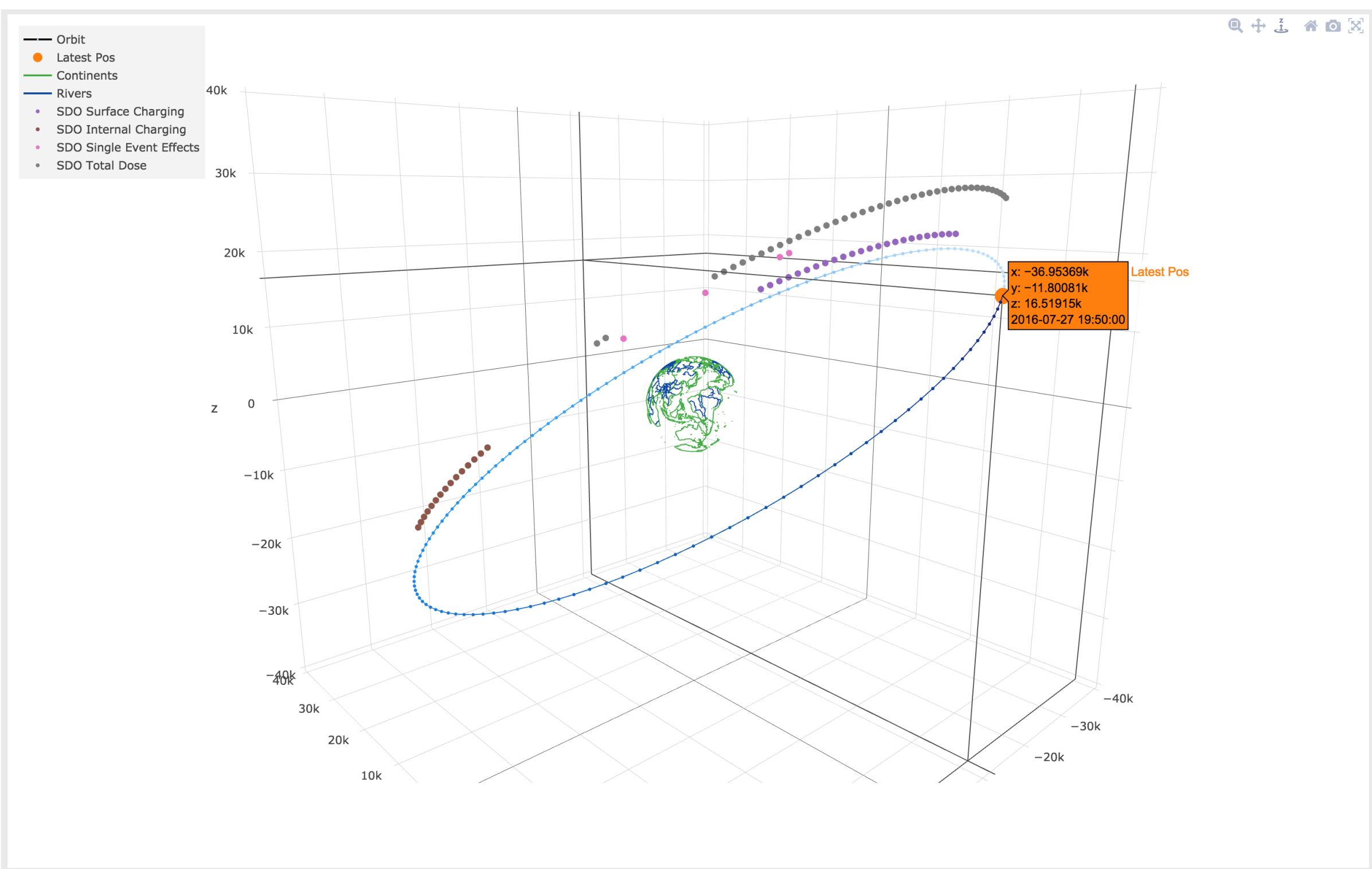
Space Environment Automated Alerts & Anomaly Analysis Assistant (SEA5) is a comprehensive analysis and dissemination system that will provide past, present, and predicted space environment information for specific missions, orbits, and user-specified locations throughout the heliosphere, geospace, and on the ground. Existing space weather resources provide global and large-scale environmental information, but presently there are no highly-tailored services that target specific missions, orbits, or locations in space for any given time period. The targeted outcome of this project is to build an extensible software system for NASA that provides an unprecedented capability for:

- Viewing space environment conditions for specific missions/orbits
- Providing automated space weather alerts for specific missions/orbits
- Assimilating and displaying spacecraft anomaly information
- Managing and displaying spacecraft/mission data

SEA⁵ Development Version



The SEA5 development version allows users to choose from an initial set of geosynchronous NASA satellites and view associated space weather products and orbit information based on the selected satellite's orbit region. After selecting a time range of interest, users can define custom thresholds for multiple space weather data products and view individual positions and times where the selected satellite experienced those conditions.



Space Radiation Environment Hazard Quotients

Hazard Quotient	Anomaly Risk	Radiation	Algorithm Data
Surface Charging	Electrostatic discharge	Thermal (<100 keV) electrons (plasma sheet, field aligned currents, 2000-0800 local time)	NOAA Kp and spacecraft local time
Internal Charging	Electrostatic discharge in cables, circuit boards, and thermal blankets	Enhanced energetic (300 keV - a few MeV) electrons	GOES primary >2 MeV electron flux
Single Event Effects	Single event latch-ups, upsets, and burn out	Heavy nuclei (cosmic rays) or high energy protons (radiation belt or solar flare)	GOES primary >30 MeV proton flux
Total Dose	Solar array anomalous degradation	Increase of dose from a Solar Proton Event or transient proton belt	GOES primary >5 MeV proton flux

SEA5's hazard quotient data products, based on Paul O'Brien's paper*, model the likelihood of an anomaly occurring on a geosynchronous spacecraft due to the radiation environment.

Interactive 3D Visualization Tool

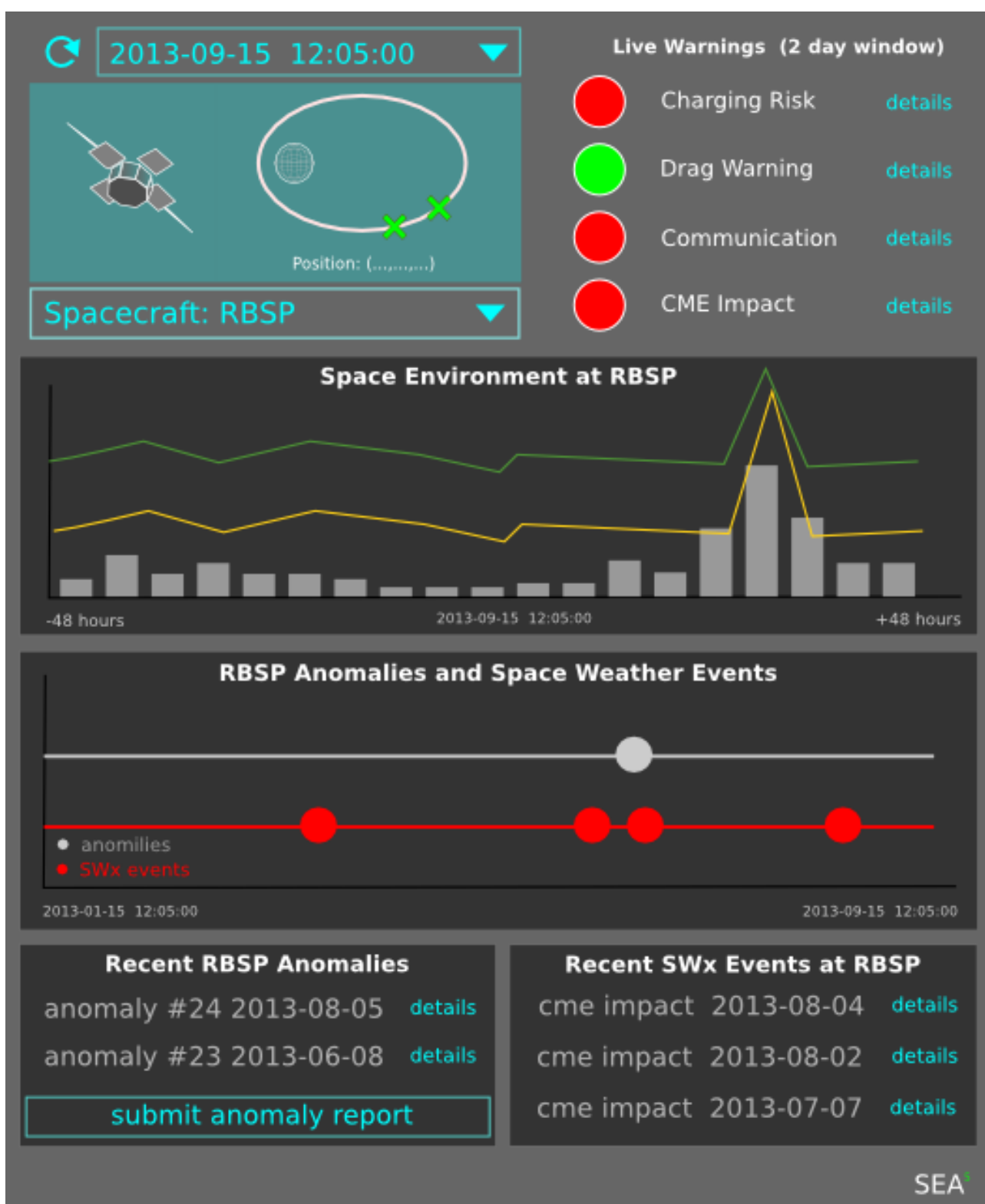
- Selected 24-hour window for Solar Dynamics Observatory (SDO) spacecraft
- Selected user-defined thresholds for various data products
- Showing positions and times SDO experienced a more hazardous environment due to Surface Charging (purple), Internal Charging (brown), Single Event Effects (pink), and Total Dose (grey)

*O'Brien, T. P. (2009), SEAES-GEO: A spacecraft environmental anomalies expert system for geosynchronous orbit, Space Weather

SEA⁵ Mockup

Web-based User Interface

- Orbit information, current location
- Impending solar storms, predicted levels of activity, and expected impacts
- Relevant space weather parameters
- Recent space weather events, spacecraft anomalies
- Real-time, automated and customizable alert functionality

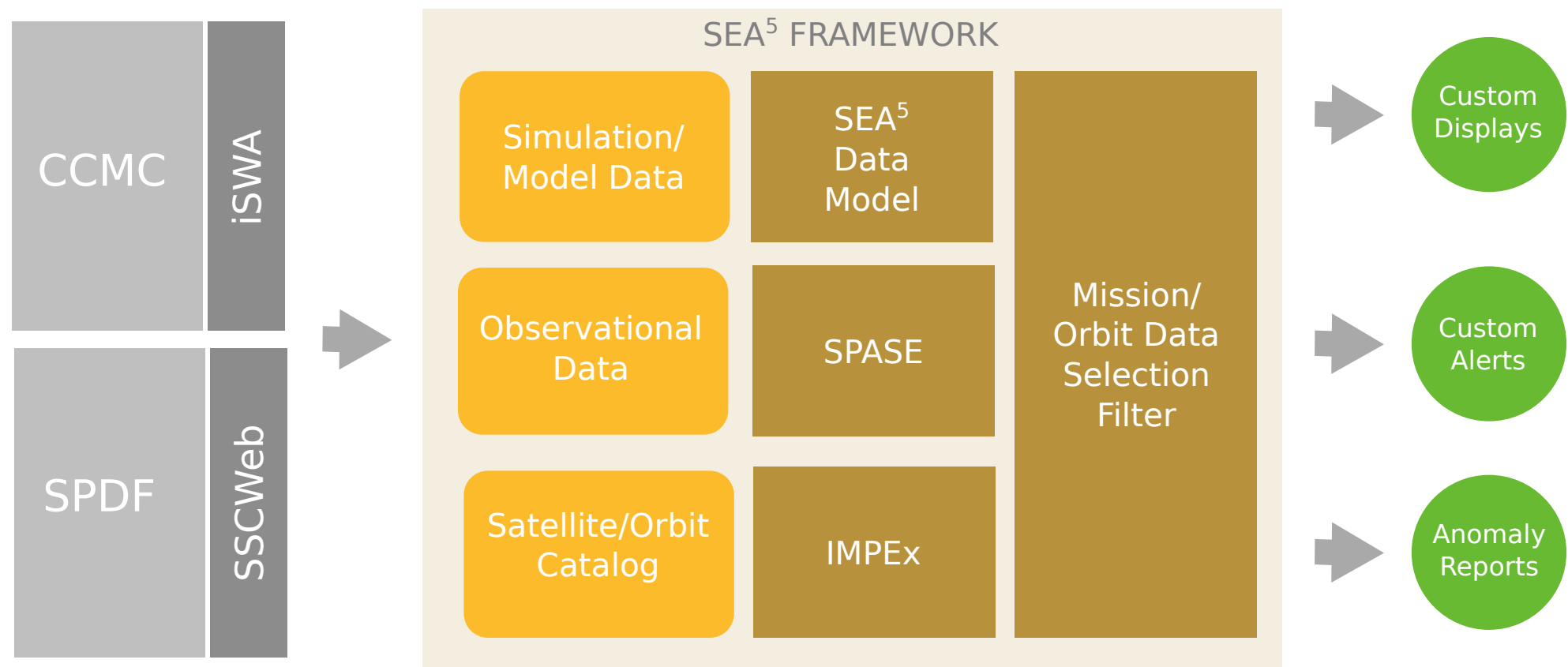


Mission specific dashboard for selected time range (Van Allen Probes/ RBSP)

SEA⁵ Framework

Architectural Design Overview

The SEA5 framework is being developed to provide space environment information for any arbitrary location throughout the heliosphere. It will include a comprehensive data model that is build on top of the SPASE standard for community-wide interoperability, and it will be easily extensible to new models, observational data, and spacecraft.



- Input: (1) CCMC real-time model output and observational data (2) Space Physics Data Facility (SPDF) satellite positions
- Framework: Extract space environment information for specific locations, dates, and times
- Output: Highly tailored displays, alerts, and anomaly reports will be presented to end users for a specific spacecraft and/or orbit

SEA⁵ Technologies

- **Web:** ThreeJS: 3D rendering with WebGL
Polymer: Web components
Plotly: Charts
- **Backend:** Embedded Jetty
Parallel Universe stack (Quasar, Comsat, SpaceBase)
Retrofit
- **Database:** PostgreSQL/PostGIS
- **Languages:** Kotlin
Java
- **Build:** Gradle

SEA⁵ Future

SEA5 is being funded by GSFC's Internal Research and Development (IRAD) program (FY17). The SEA5 development team is in the process of publishing a development version of SEA5 on the NASA network and will continue to push updates throughout development for users to test and provide feedback. In the future, we will expand SEA5's framework to extract space environment information from 3D global simulation codes to provide significant heliospheric environmental coverage for spacecraft. We will also increase mission support with the ultimate goal of supporting ALL NASA missions past and present.